Application Note

Pentium® III Xeon™ Processor at 600MHz+ EMI Guidelines

Application Note - 970

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1. INTRODUCTION

This Application Note is intended to provide information that will help the system designer contain electromagnetic emissions from 600MHz+ Pentium® III Xeon™ processor platforms, and it focuses in particular on processor heatsink grounding as a possible EMI containment approach.

Intel has developed a proof-of-concept *heatsink ground clip* prototype which has been shown to attenuate radiated emissions by up to 5dB (at a given frequency) on Pentium® III Xeon™ processor platforms. Results will depend upon the type of material used to fabricate the heatsink ground clips, the dimensional design of the clips, and the effectiveness of the connection to both the processor heatsink and the motherboard electrical ground.

The *heatsink ground clip* for EMI suppression is a *proof-of-concept* design only, and would need to be tailored to individual system implementations. **Intel has no plan to perform an industry enabling function for these heat sink ground clips.**

Other methods to be considered for attenuating emissions include taking advantage of existing design margins, adding shielding, adding EMI gasket material, adding additional ground points near the processor, grounding the thermal plate of the processor, and using design techniques at the board and system levels to attenuate emissions.

2. TERMINOLOGY

The following terms are used in this document and are defined here for clarification:

- **Pentium® III Xeon™ processor at 600MHz+ -** refers to Pentium III Xeon Processors which utilize On Cartridge Voltage Regulator technology, or ***"OCVR"*** and operate at frequencies equal to or greater than 600MHz. The OCVR regulates V_{CC_CORE} (the appropriate cartridge input voltage) to the required processor core voltage (V_{CC_CPU}). The OCVR was developed to provide the necessary regulation to guarantee the highest possible frequency of operation for the Pentium III Xeon processor at 600MHz+.
- **Pentium® III Xeon™ processor -** refers to a Pentium III Xeon Processor at 500MHz or 550MHz, a 100MHz system bus, without an OCVR, and requires separate Vcc CORE & L2 voltage sources.
- **L2 cache** —The L2 cache is integrated directly on the processor core for the 600MHz+ Pentium III Xeon processor, or is located on the substrate for the Pentium III Xeon processor.
- **2.8V Pentium III Xeon processor** — refers to a 600MHz+ Pentium III Xeon processor which can be powered with +2.8 volts applied to its VCC_CORE pins.
- **5/12V Pentium III Xeon processor** — refers to a 600MHz+ Pentium III Xeon processor which can be powered with either +5.0 or +12.0 volts applied to its VCC_CORE pins.
- **Processor substrate** — The structure on which components are mounted inside the S.E.C. cartridge (with or without components attached).
- **Processor core** — The processor's execution engine.
- **S.E.C. cartridge** — The processor packaging technology used for the Pentium III Xeon processor family. S.E.C. is short for "Single Edge Contact" cartridge.
- **Thermal plate** — The surface used to connect a heatsink or other thermal solution to the processor.

3. REFERENCES

The reader of this Application Note should also be familiar with material and concepts presented in the following documents:

- *Pentium® III Xeon™ processor Specification Update* (Order Number 244460)
- *SC330 Processor Enabling Technology Vendor List* (www.developer.intel.com)
- *330-Contact Slot Connector (SC330) Design Guidelines* (http://developer.intel.com/design/pentiumii/xeon/designgd/index.htm)
- *VRM 8.3 DC/DC Converter Guidelines* (http://developer.intel.com/design/pentiumii/xeon/designgd/index.htm)
- *Flexible Motherboard Power Distribution & Control for Pentium® III Xeon™ Processors* (Order Number 245245)

4. EMI CONTAINMENT APPROACHES

This document will focus on grounding of the 600MHz+ Pentium® III Xeon™ processor heatsink as a method to contain EMI emissions. There are multiple methodologies that can be used to ground the heatsink. Two conceptual approaches will be described in this document. However, these approaches are *proof-of-concepts* only, and will need to be tailored to a particular OEM system implementation (chassis, Retention Mechanism (RM), and heatsink).

4.1 Spread Spectrum Clocking

While the focus of this document is on heatsink grounding approaches, Intel also recommends using *Spread Spectrum* clock (SSC) generation on the motherboard to further reduce radiated EMI in systems based on the 600MHz+ Pentium® III Xeon™ processor.

SSC is widely used in desktop systems today to reduce EMI emissions. But because of possible timing issues, server and workstation platform designers have been reluctant to incorporate SSC into their systems. However, issues associated with SSC have significantly been reduced in the latest generation of processors and selected chipsets. Designers need to determine the compatibility of their systems with SSC. Present SSC implementations can provide up to approximately 8 to 10 dB of radiated EMI suppression at all frequencies derived from the spread spectrum clock.

Spread Spectrum clock generators are available from several vendors. Please contact the vendor of your choice. Information on the following clock vendors and their products can be found at the URLs shown below:

Cypress Semiconductor, Inc.
3901 North First Street
San Jose, CA 95134
U.S.A.
Tel: (408) 943-2600
Fax: (408) 943-2741
http://www.cypress.com/contacts/offices/index.html

IC WORKS, Inc.
101 Nicholson Lane
San Jose, CA 95134-1359 USA
TEL: 408-922-0202
FAX: 408-922-0833
http://www.icworks.com/about/sales/us-sales-reps.html

4.2 Heatsink Grounding

There are several considerations when implementing the *heatsink ground clips* described in this document as a method of reducing radiated EMI emissions. First, the processor *Retention Mechanism* (RM) mounting holes on the motherboard must incorporate a *ground ring* pad so that the heatsink clips can make a sufficient electrical connection to the motherboard ground. Second, there may be physical keep-out zone restrictions associated with implementing heatsink ground clips depending upon a particular motherboard layout and chassis implementation.

4.3 Motherboard Ground Ring Pads

Below is an example of the RM mounting hole *ground ring* pads implemented on the Intel SC450NX* motherboard used in obtaining the measured *heatsink ground clip effectiveness data* shown in Graph 1 of this document.

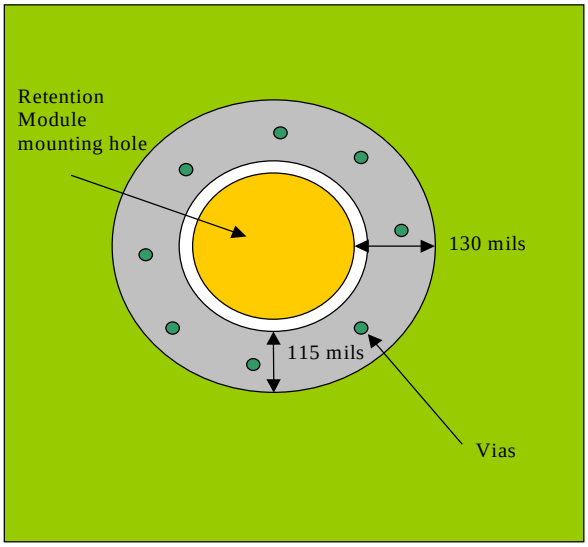


Figure 1. RM mounting hole Ground Ring Pad dimensions.

***NOTE: The SC450NX is a 4-way, Intel® 450NX PCIset-based server motherboard.**

4.4 Requirements for Heatsink Ground Clip-Ready Retention Mechanism

The Retention Mechanism (RM) must make contact with the primary side of the motherboard ground ring pads, and the RM must make adequate contact with the 600MHz+ Pentium® III Xeon™ processor heatsink.

4.5 Possible RM Solutions

It may be necessary to add slots to the Intel approved RM (part# 699341-001, rev 05) to allow the heatsink ground clips to contact both the heatsink and the motherboard. RM slots are required if keep out zone restrictions prevent allowing the clip to go outside the RM volume area. The RM can be modified to allow the heatsink ground clips to *slide through* from the bottom of the RM or to *wrap around* the RM to contact the heatsink, as shown in figure 2.

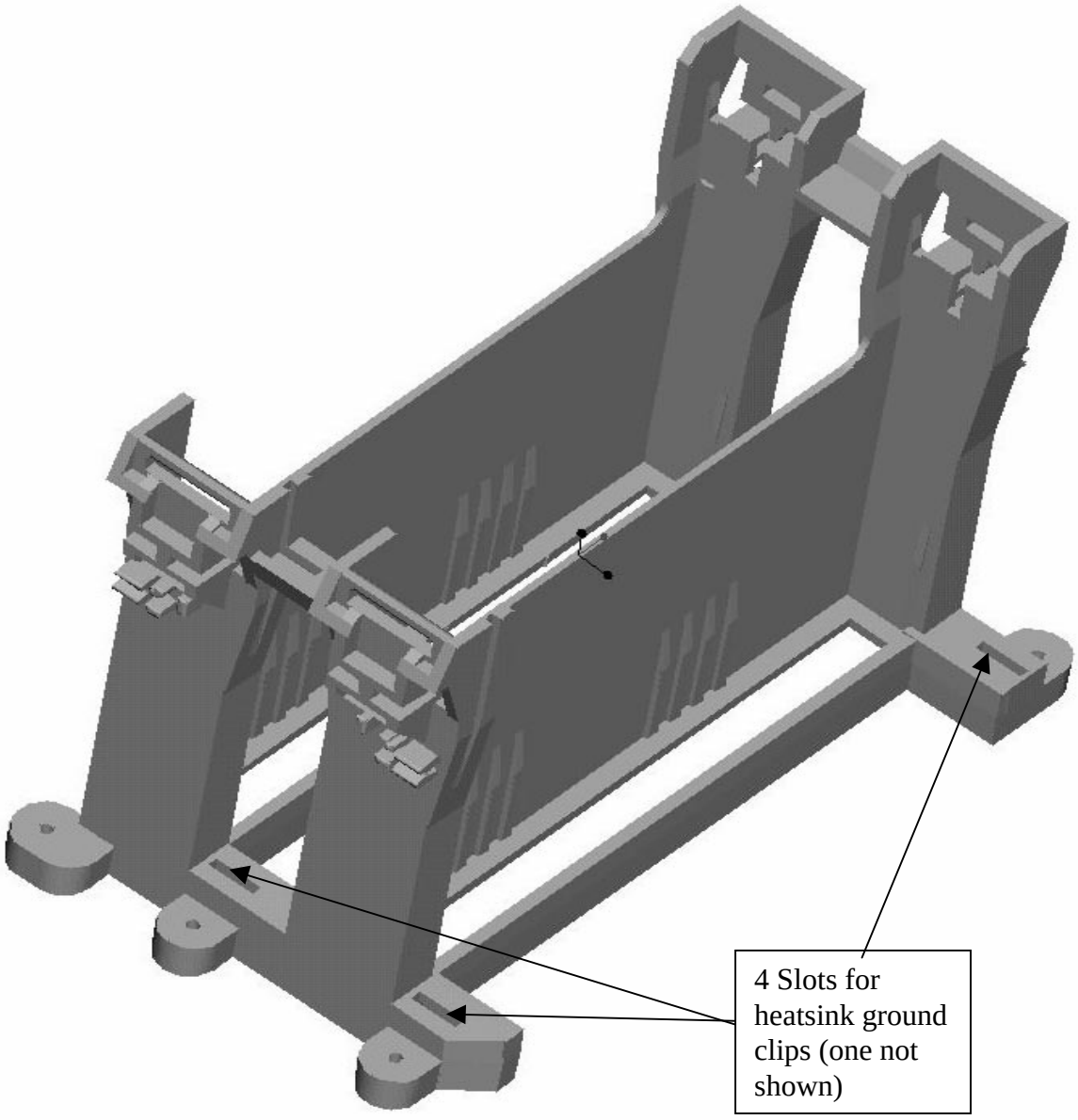


Figure 2. Heatsink Ground Clip modified RM

Recesses also need to be added to the bottom of the RM where the heatsink ground clip will make contact with the motherboard to maintain back out and SECC vertical height restrictions (see figure 3), regardless of the type of heatsink ground clip chosen.

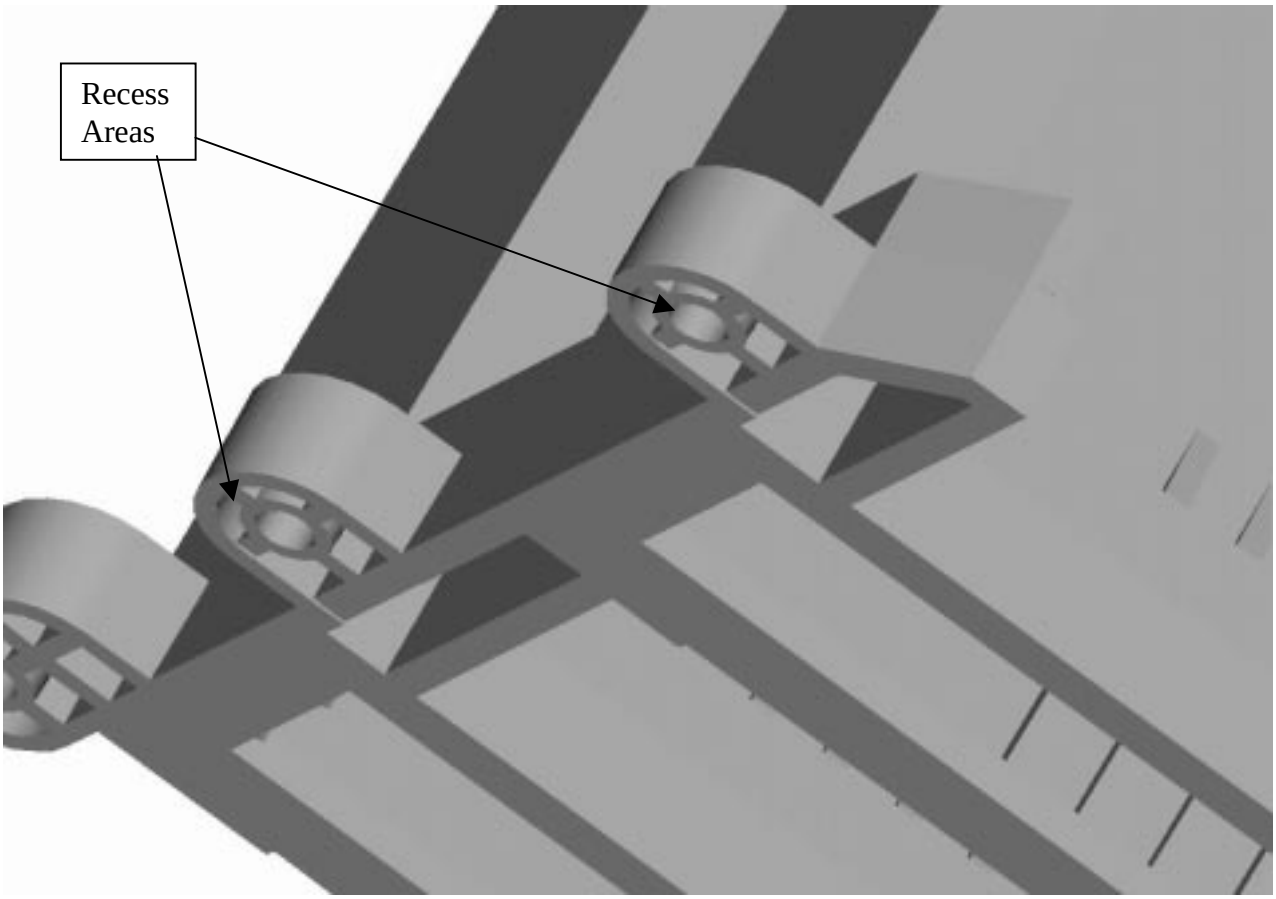
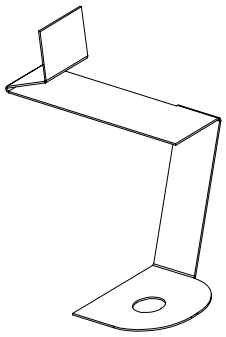


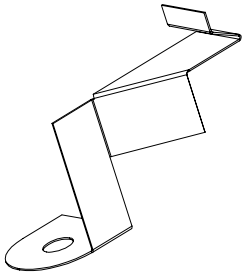
Figure 3. Ground clip will pass through holes and touch heatsink

NOTE: Either (slide through or wrap around) heatsink clip solution will add parts to the assembly process at the motherboard level, unless the heatsink clip is captive on the RM.

4.6 Heatsink Ground Clips



Slide-through



Wrap-around

Figure 4. Two styles of Heatsink Ground Clips.

The heatsink ground clip can wrap around the RM (see figures 5 & 6) if they do not violate any board keepout area, but the bottom recess (see figure 3) will still need to be made in the RM, so that it will not cause tilting of the RM or raise the intended height of the RM off the motherboard.

Heatsink ground clip design is critical to the effectiveness of the clips. The clip performance deteriorates with the length of the clip. Consequently, the clip design should target the shortest path from the heatsink to the motherboard ground.

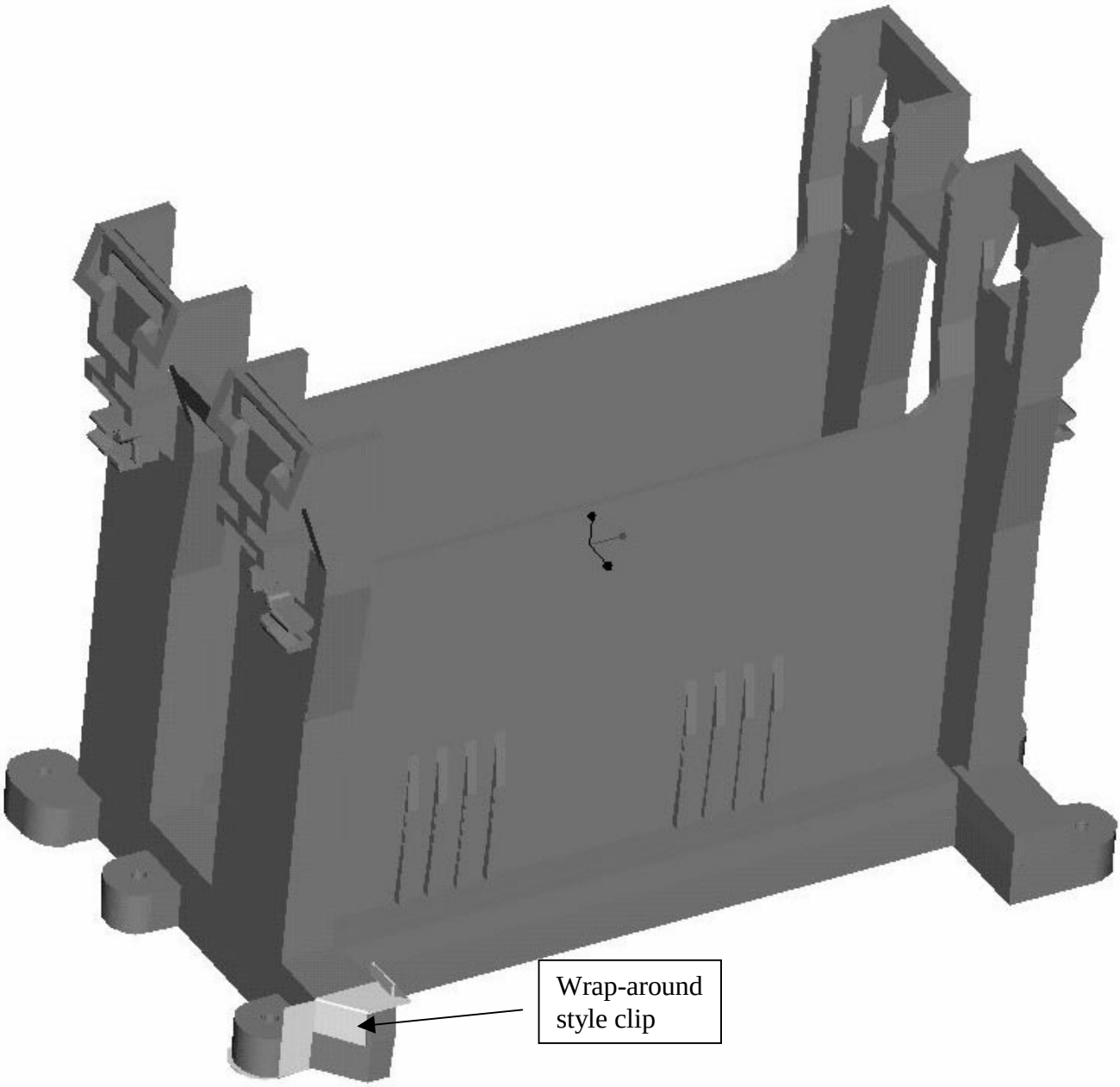


Figure 5. Heatsink Ground Clip installed outside of RM (wrap-around).

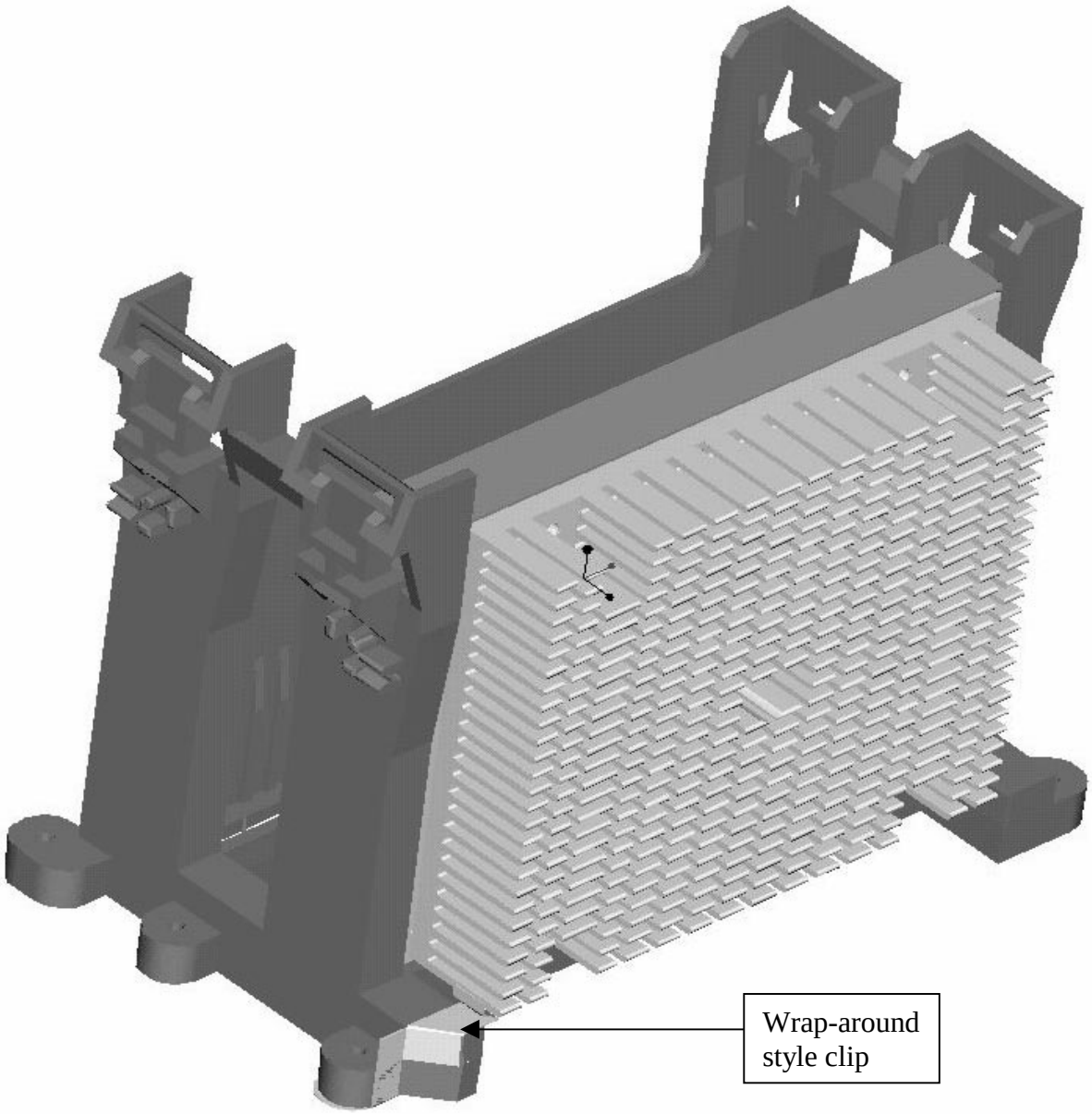


Figure 6. Heatsink makes contact and spring loads the Ground Clip.

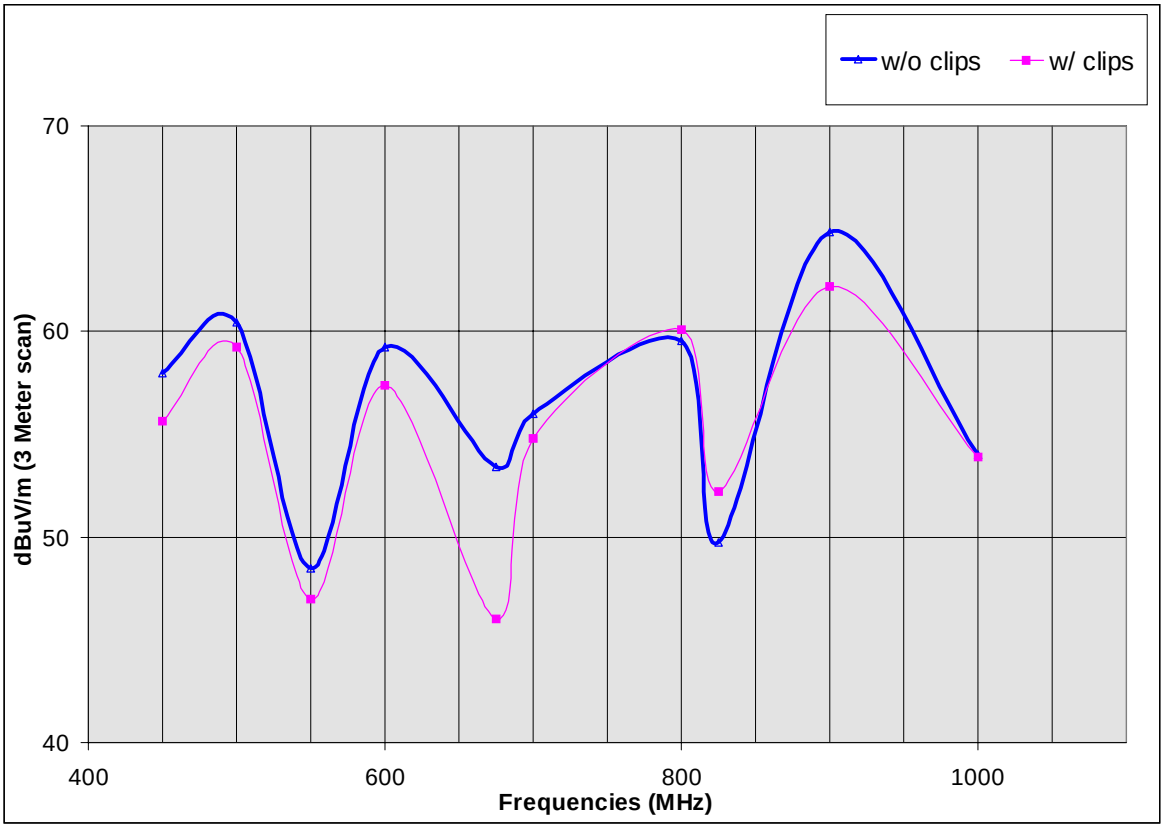
4.6.1 Heatsink Ground Clip Material

260 cartridge brass sheet metal, 0.01” thick was used for the *proof-of-concept* heatsink clip prototype.

Intel recommends that a production heatsink clip design be made of a material with conductivity properties of 260 cartridge brass or equivalent. The thickness of the material can vary, but should be robust enough not to exceed the yield strengths of the material selected when the EMI clip is deflected by a contact load from the heatsink. The load force from the heatsink to the EMI clip should be greater than 10 grams to guarantee contact is made and sustained.

4.6.2 Heatsink Ground Clip Effectiveness Measurements

The heatsink ground clip effectiveness data for Graph 1 was obtained from an Intel SC450NX motherboard with RM 669341-001 (as described in section 4.5) and a **Pentium® III Xeon™ processor running at 450/100 MHz.**



Graph 1. Heatsink Ground Clip effectiveness.

5. EMI MEASUREMENTS

This section discloses measured EMI data obtained from 600MHz+ Pentium® III Xeon™ processors on a 2-way/133MHz platform.

5.1 Critical processor frequencies

The highest radiated emission from the 600MHz+ Pentium® III Xeon™ processor has been observed at the second harmonic of the processor core. For example if the processor runs at 600MHz, the second harmonic would be 1200MHz.

Radiated emissions are also observed at the half clock frequency harmonic. For example with the processor core running at 600MHz, radiated emissions are observed at 900MHz and 1500MHz. Radiated emissions are also a function of how the system and the processor cartridge resonate. With 600MHz+ Pentium® III Xeon™ processors, the fundamental frequency ranges from 600 to 866MHz, and the second harmonic is from 1200 to 1732MHz. Processor emissions at a specific harmonic are expected to go up by 6+dB with the doubling of frequency. Radiated emissions on a 4-way processor system are about 3-5 dB higher compared to a single or 2-way processor system utilizing the same system solution.

Chassis level EMI containment is very unique to a system design, and therefore, will define the ultimate noise level of the system after containment, and thus the cartridge emissions. Also, emissions off other components in a system, for example the system bus, can potentially have higher emissions at the processor core frequencies and its harmonics and thus mask the processor emissions.

5.2 Measurement set-up

The Intel BR840 motherboard was used to perform internal validation of the 600MHz+ Pentium® III Xeon™ processors, and to perform EMI testing. The peripherals attached to the BR840 based system were mouse, keyboard and monitor. *Closed Box* (in Table 1) is defined as a *Closed Intel BR840 chassis*. *Open Box* (in Table 1) is defined as an *Open Intel BR840 chassis (*one side off with silver box panel open).

The chassis was oriented vertically (standing up), with the processors facing the 1.5 meter antenna.

NOTE: The BR840 is a 2-way Intel® 840 PCIset-based Workstation motherboard.

5.3 Measured EMI Data

Frequency (in MHz)	***600***	***1200*** ***(2nd harmonic of 600MHz)***	***667***	***1334*** ***(2nd harmonic of 667MHz)***	***733***	***1466*** ***(2nd harmonic of 733MHz)***	***800***	***1600*** ***(2nd harmonic of 800MHz)***	***866***	***1732*** ***(2nd harmonic of 866MHz***	***Notes***
Case 1	**64**	**74**	**60**	**67**	**51**	**68**	**61**	**78**	**50**	**79**	2-way, *Open Box*
Case 2	**-**	**-**	**41**	**49**	**-**	**-**	**45**	**63**	**31**	**62**	2-way, *Closed Box*
Case 3	**-**	**-**	**62**	**61**	**-**	**-**	**-**	**-**	**-**	**-**	Single, *Open Box*

Table 1. 600, 667, 733, 800, and 866MHz measured EMI data [1,2,3,4]

NOTES:

1) All numbers in dBuV/m (peak).
2) Scan range = 30MHz through 2 GHz.
3) There is an approximate 3dB measurement error in the results of Table 1.
4) The above results indicate that the Intel BR840 chassis, when in a closed box configuration, provides good radiated EMI attenuation. However, the closed box data should NOT be taken as an indication that all chassis, when closed, will perform similarly.

5.4 Analysis

Table 1 data shows that core frequency emissions do not change proportionally even with a significant increase in processor frequency (from 600 MHz to 866 MHz). This is because emissions are also a function of the system on which the tests are done. It should also be noted that there is a 3dB margin of error on lab measured data. Therefore, differences in consecutive measurements of the same system are typical.

6. EMI SUMMARY

Initial test results shows that properly designed heatsink ground clips **may** provide radiated EMI suppression of approximately 5 dB at the processor fundamental frequency and its harmonics.

System designers should consider incorporating heat sink grounding clips to reduce EMI in 600MHz+ Pentium® III Xeon™ processor platforms, as well as implementing Spread Spectrum Clock technology onto their motherboard designs.

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